# High Resolution Site Characterization and In Situ Remediation in a Complex Fracture-Flow Regime

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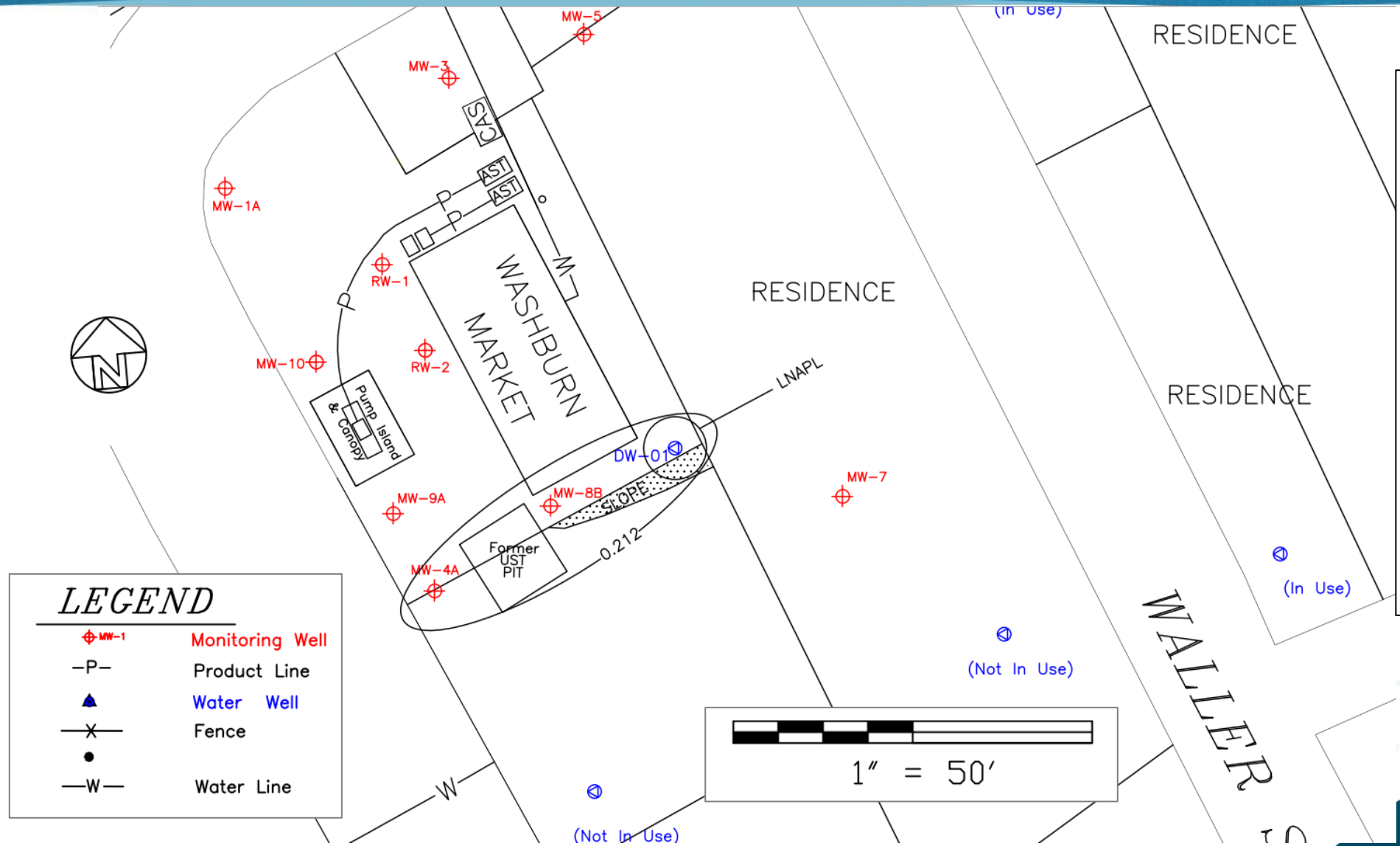
# Site Background

- Rural Retail Petroleum Station with Grocery Store
  - Numerous drinking water receptors w/in 300-feet
  - Release discovered in 1996, LNAPL recovery via Pump & Treat and MEME performed until 2008
  - DPE operated between 2009-2017 with limited success; COCs and LNAPL rebound when system turned of
  - TDEC began research of suitable technologies to remediate dissolved-phase impacts and LNAPL in fractured bedrock

# Site Background (cont.)

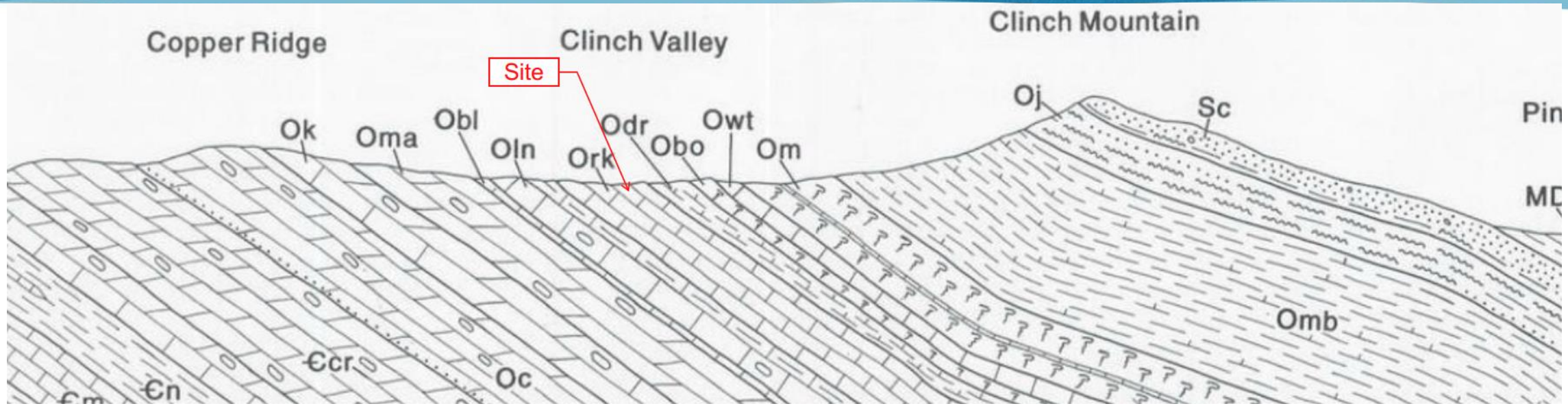
- Geology
  - Valley and Ridge Physiographic Province of Tennessee
  - Fine-grained (clay and silt) overburden varying 10’ to 29’ thick
  - Ordovician Calcarenitic Limestone – Pine Mountain Thrust Sequence
  - Groundwater 12’ to 27’ bgs
    - Overburden aquifer not present across much of site
    - Shallow bedrock aquifer

# Site Background (cont.) – CSM 2Q2017




- Dissolved Benzene Plume
  - Site-specific clean-up goal 0.212 mg/L
- LNAPL persistence in on-site Domestic-use well
- Off-site access restricted (revoked) east of facility

# Site Background (cont.) – CSM 2Q2017




# Existing CSM 2Q2017

Contaminant F&T Geologically Controlled

- Plume orientation parallel to strike

No Characterization of Aquifer

- Existing well network limited to sampling or extraction
  - Cased wells with constructed filterpack, long screened intervals
  - Boreholes advanced via air rotary, no cores to log geology

Elevated Screening Levels

- Sorbed impacts not considered

# Remedial Objectives

- TDEC requested an alternative Remedial Action Plan
  - Reduction in groundwater VOC concentrations below RBCLs
  - Protection of GW beyond the property line (east of DW-1)
  - Mitigation of LNAPL in the on-site domestic-use well (DW-1)

- AST contracted in 2017 to provide a remedial solution
  - Preliminary Design based on existing CSM for budgeting
  - Remedial Approach: Rapid Characterization, Evaluation, and Revised Design
  - LNAPL and Plume Treatment – Trap & Treat® BOS 200®

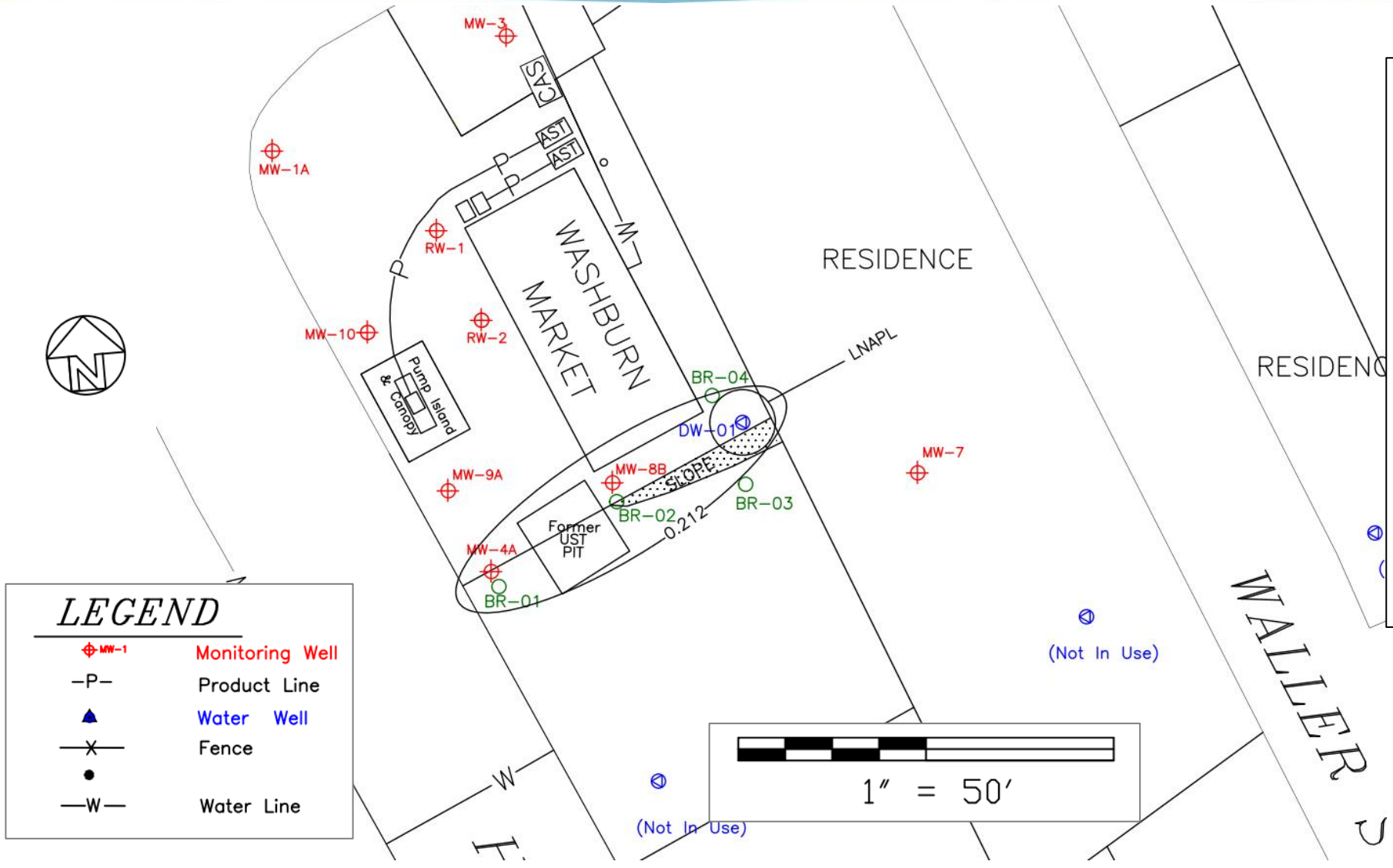
# Remedial Approach

## Remedial Design Characterization

- Surface Geophysics – 2D-ERI
- Confirmatory Soil Sampling
- Aquifer Characterization
  - Well Installation – aquifer testing and in-situ injection
  - Downhole Geophysics and Imagery
  - Groundwater Survey – hydraulics and chemistry

## In-situ Injection

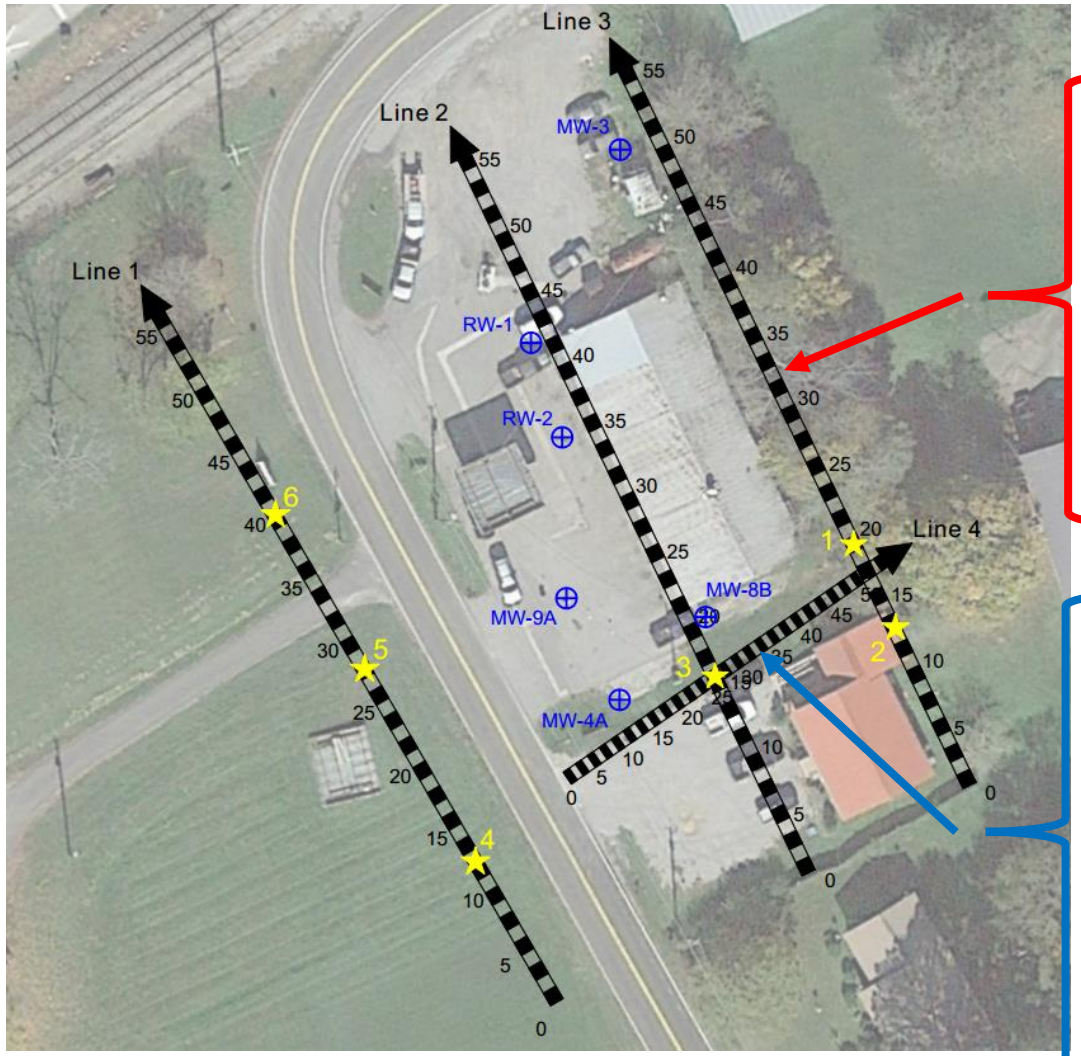
# Preliminary Design

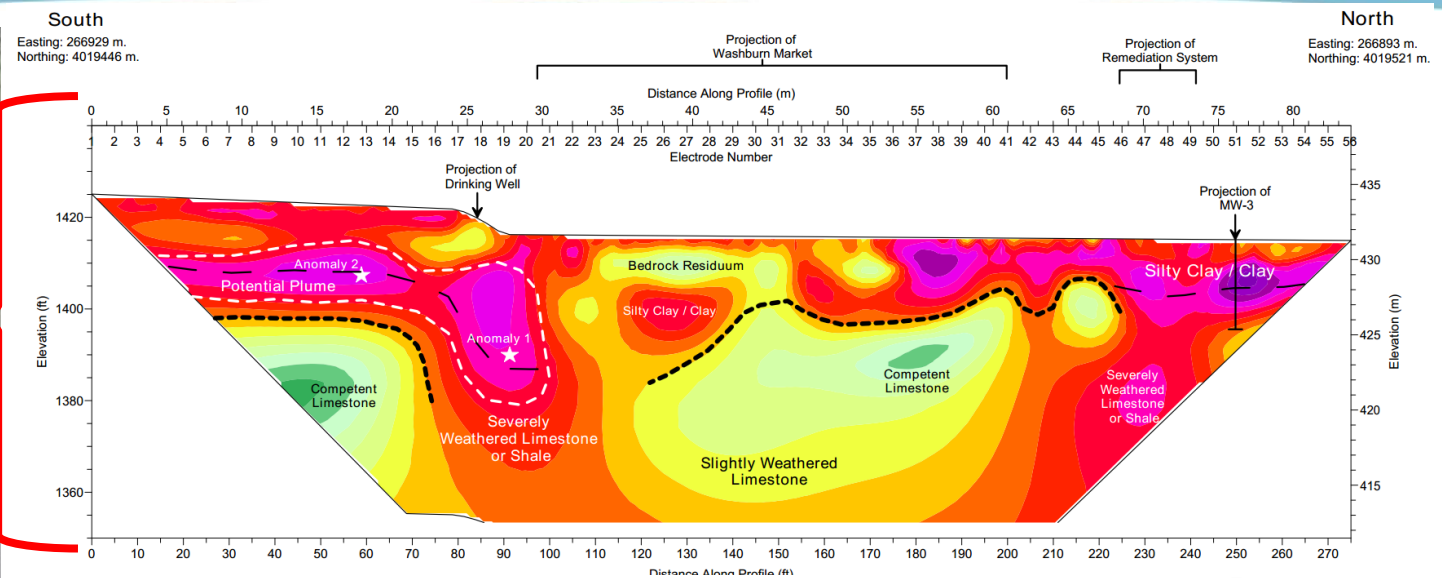


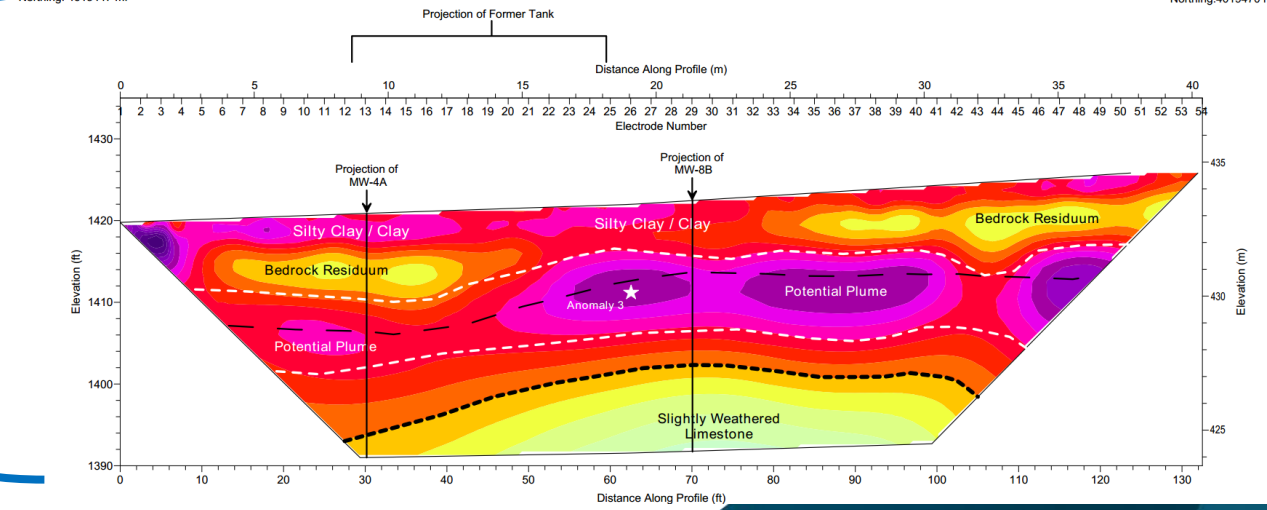

Open Borehole Wells

- 8” steel casing 1’ to 5’ into rock
- 6” open borehole to 60’ bgs
- Locations and orientation confirm using 2D-ERI Survey

# Remedial Design Characterization (RDC) – 2D-ERI



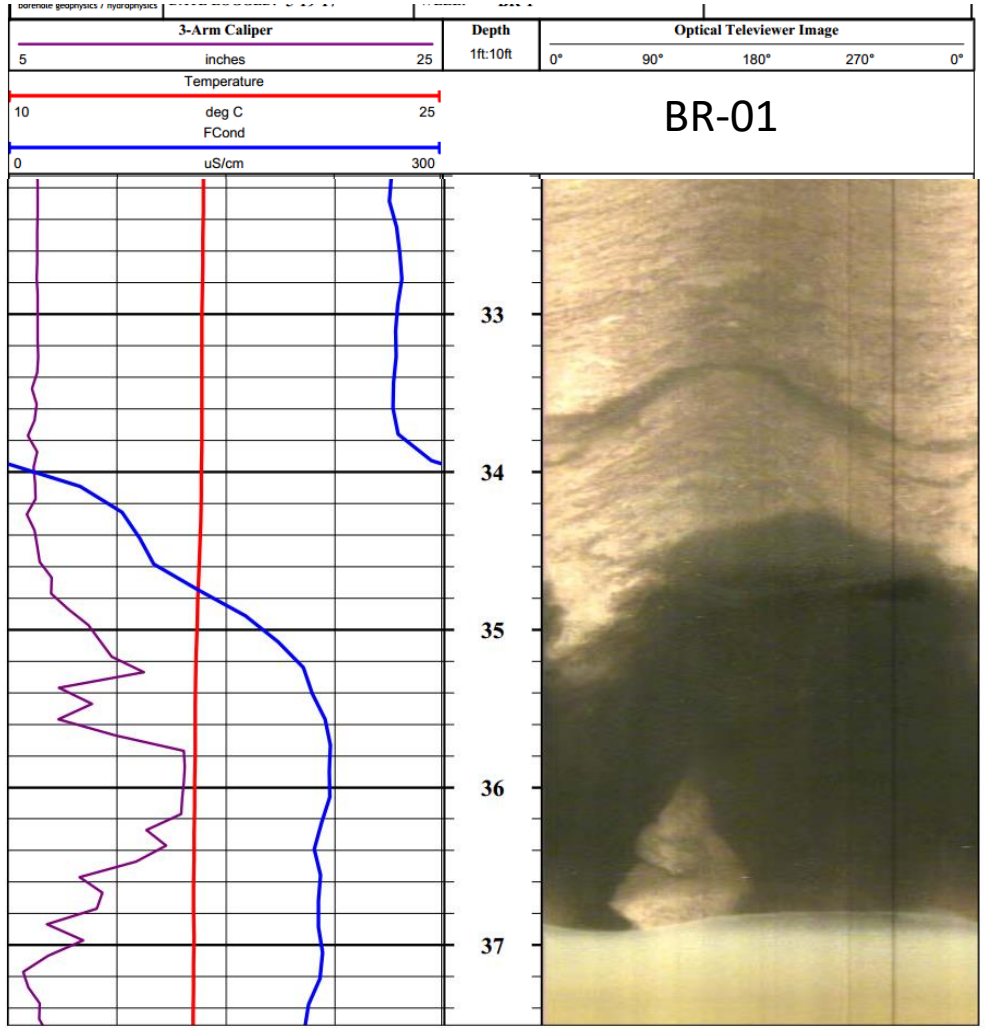



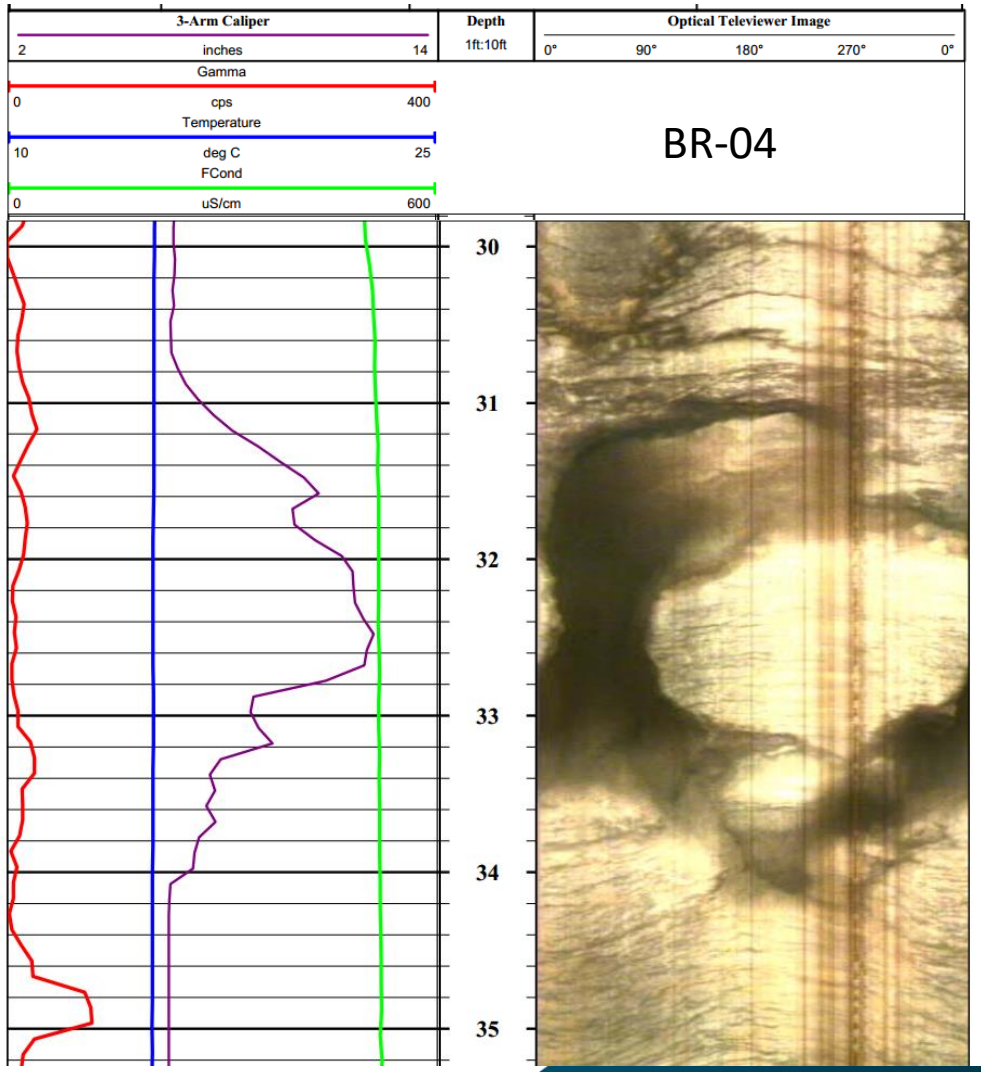



# RDC – Sonic Drilling and Rock Coring



# RDC – Downhole Geophysics



# RDC – Aquifer Characterization

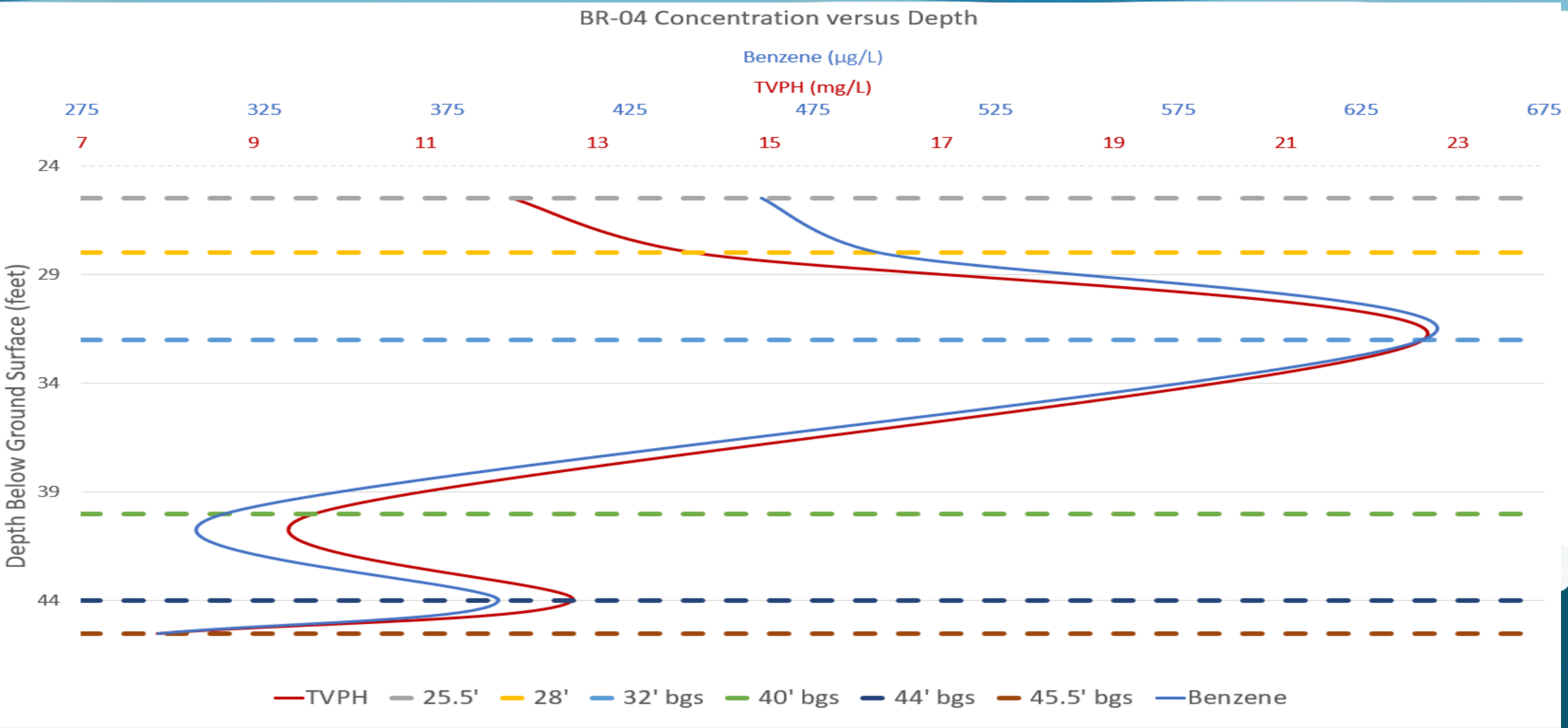

Pressure Transducer Above Discrete Interval

Pressure Transducer w/in Discrete Interval

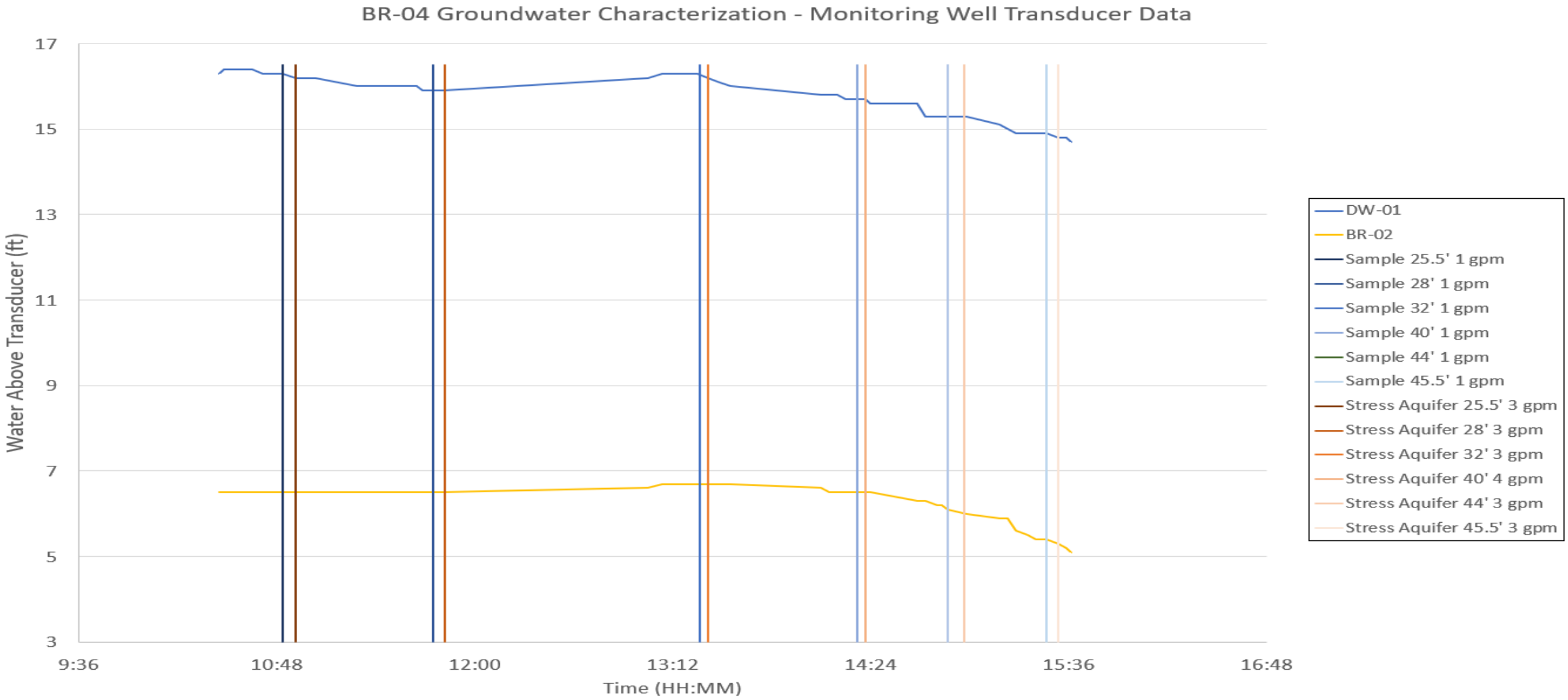
Grundfos Rediflo 2

Pressure Transducer Below Discrete Interval


# RDC – Aquifer Discrete Sampling and Stress



# RDC – Aquifer Discrete Sampling and Stress (cont.)



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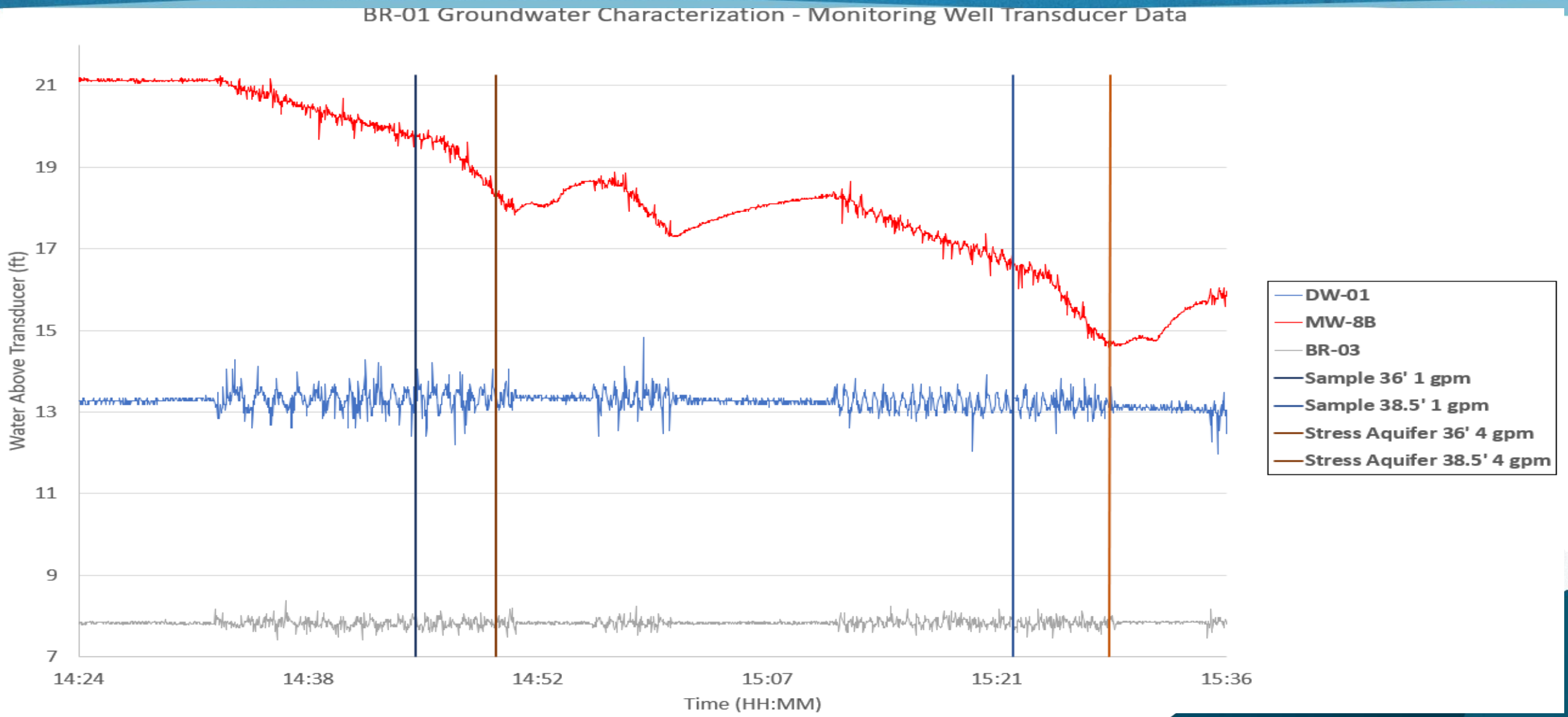

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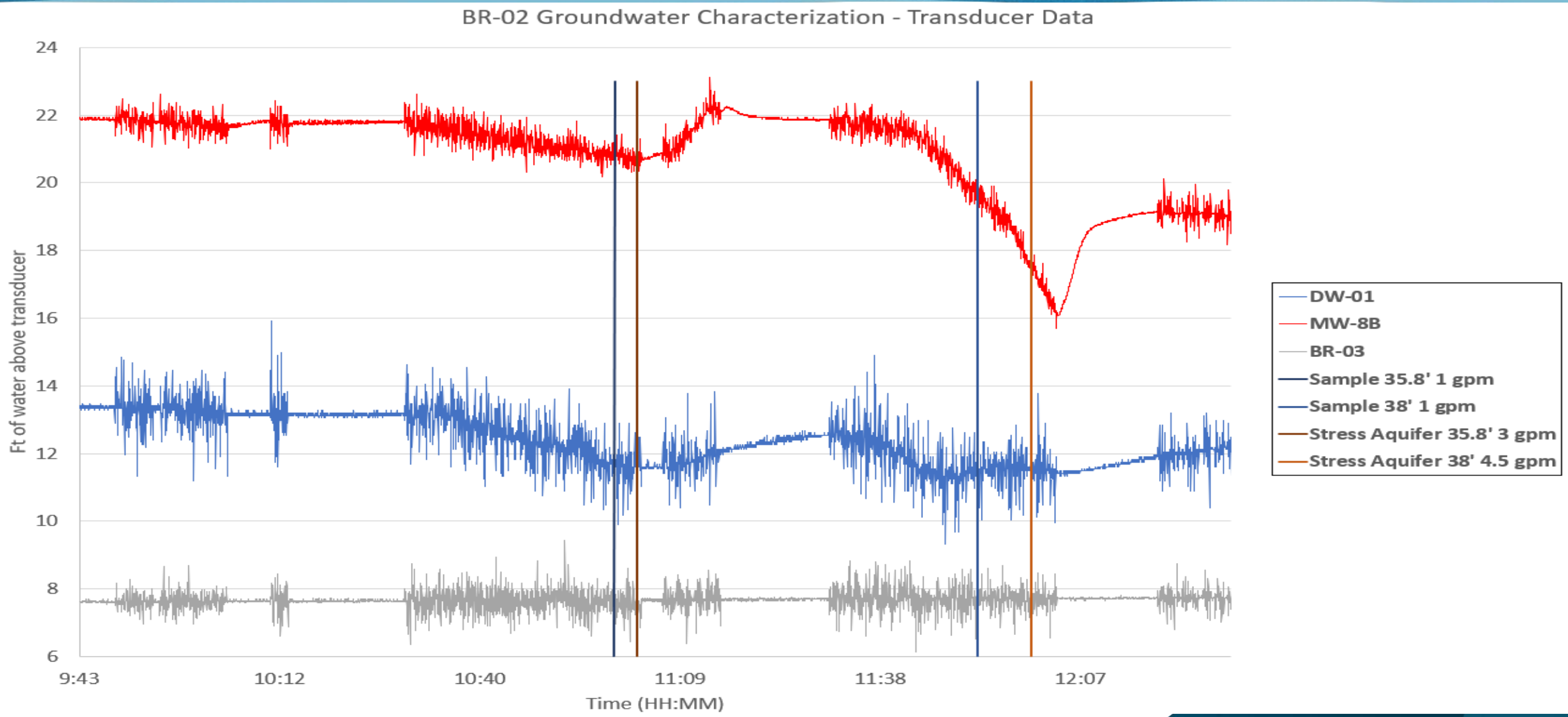
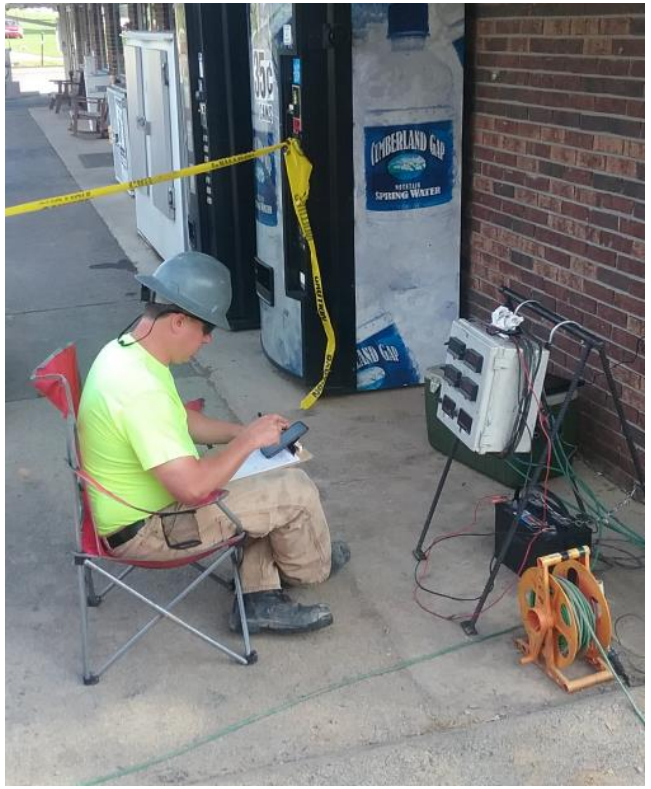


# Revised Design and In-Situ Injection

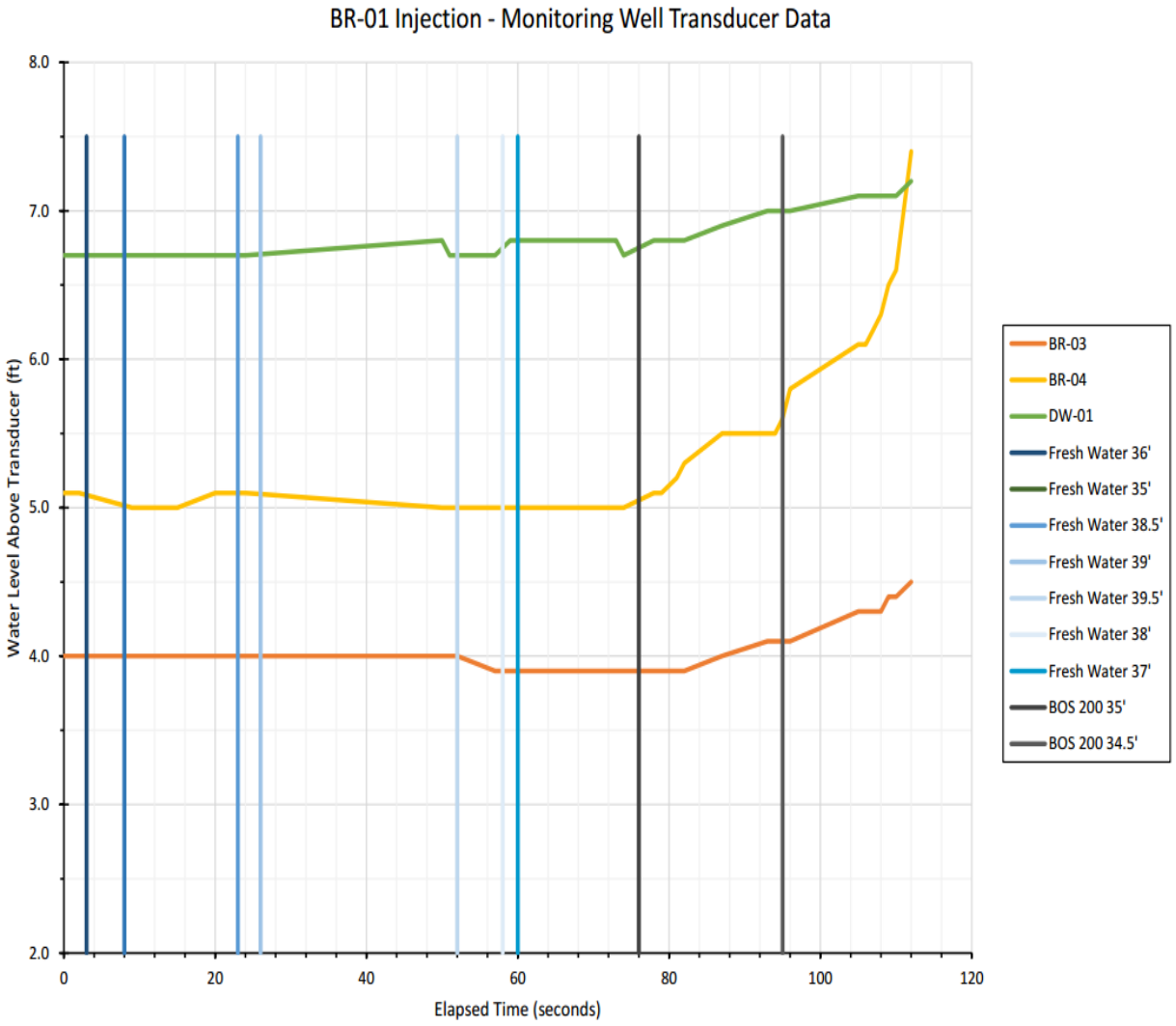
- Preliminary Design Pre-RDC
  - Contingency plan for limited overburden treatment – potential soil mass contribution
  - Up to twelve (12) injection intervals in consolidated material – 15’ to 60’ bgs
    - Unknown frequency of secondary porosity features
  - Uniform distribution of reagent site wide – assumption that mass extent uniform

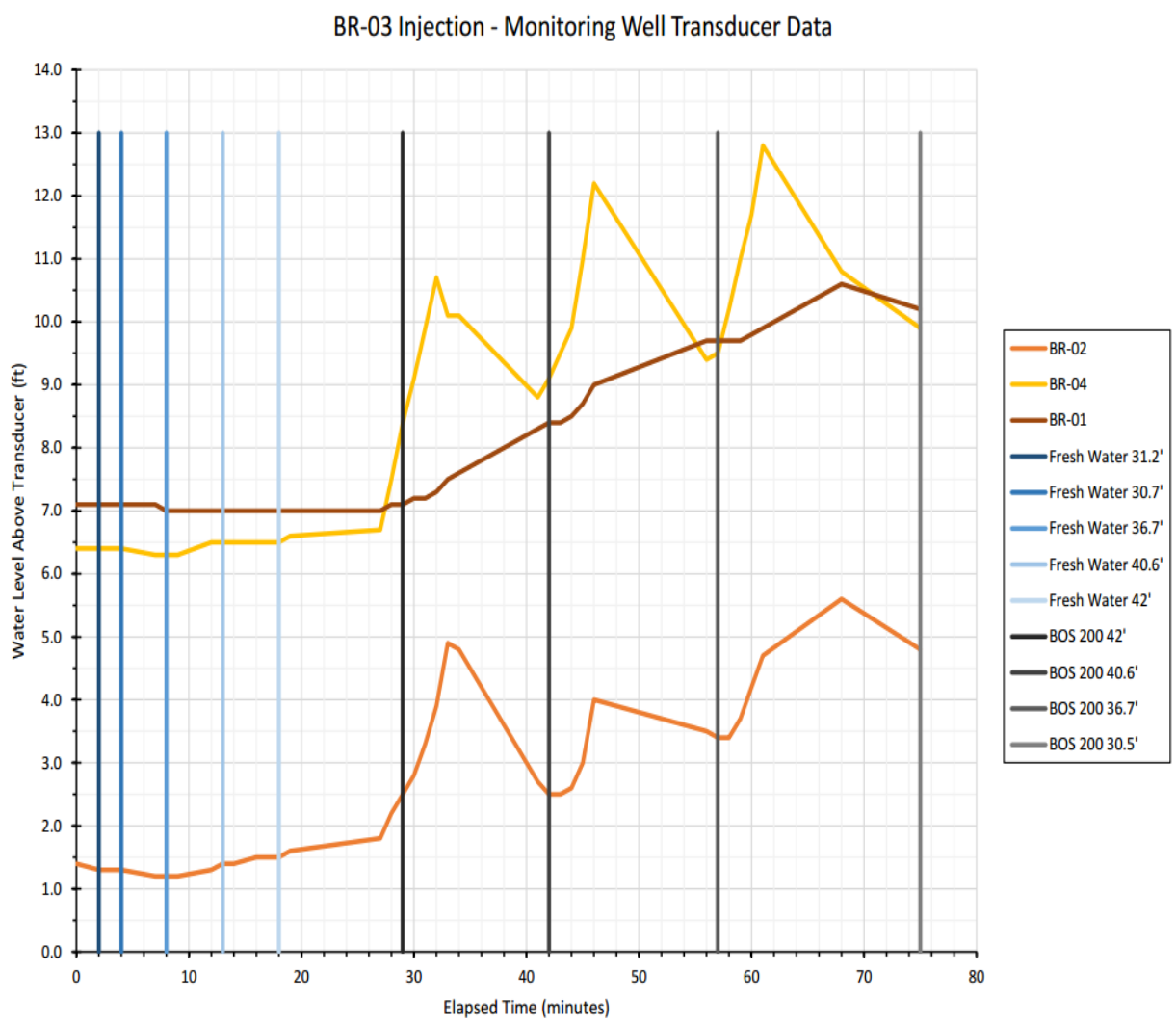
- Revised Design Post-RDC
  - No overburden treatment – minimal impacts remaining, negligible contribution
  - Four (4) to six (6) intervals in consolidated media
    - Intervals selected based on permeability and mass present
  - Trap & Treat® BOS 200® varied with each interval

# In-Situ Injection



# In-Situ Injection (cont.)



# Closing Comments…

- Notice to Proceed → Remediation Implementation: 43-days
- LNAPL Eliminated from on-site domestic-use well immediately following injections
- MCLs met and maintained w/in the existing monitoring well network, anions showed progression of active bioremediation
- No Further Action memo issued for facility in late December 2017

Questions?

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